International Telecommunication Union

ITU-R

Radiocommunication Sector of ITU

Report ITU-R BT.2296-0

(11/2013)

Example of application of Recommendation ITU-R BT.1895 and Report ITU-R BT.2265 to assess interference to the broadcasting service caused by the impact of IMT systems on existing head amplifiers of collective television distribution systems

BT Series

Broadcasting service (television)

International Telecommunication Union

Foreword

The role of the Radiocommunication Sector is to ensure the rational, equitable, efficient and economical use of the radio-frequency spectrum by all radiocommunication services, including satellite services, and carry out studies without limit of frequency range on the basis of which Recommendations are adopted.

The regulatory and policy functions of the Radiocommunication Sector are performed by World and Regional Radiocommunication Conferences and Radiocommunication Assemblies supported by Study Groups.

Policy on Intellectual Property Right (IPR)

ITU-R policy on IPR is described in the Common Patent Policy for ITU-T/ITU-R/ISO/IEC referenced in Annex 1 of Resolution ITU-R 1. Forms to be used for the submission of patent statements and licensing declarations by patent holders are available from http://www.itu.int/ITU-R/go/patents/en where the Guidelines for Implementation of the Common Patent Policy for ITU-T/ITU-R/ISO/IEC and the ITU-R patent information database can also be found.

Series of ITU-R Reports

(Also available online at http://www.itu.int/publ/R-REP/en)

Series	Title
BO	Satellite delivery
BR	Recording for production, archival and play-out; film for television
BS	Broadcasting service (sound)
BT	**Broadcasting service (television)**
F	Fixed service
M	Mobile, radiodetermination, amateur and related satellite services
P	Radiowave propagation
RA	Radio astronomy
RS	Remote sensing systems
S	Fixed-satellite service
SA	Space applications and meteorology
SF	Frequency sharing and coordination between fixed-satellite and fixed service systems
SM	Spectrum management

***Note**: This ITU-R Report was approved in English by the Study Group under the procedure detailed in Resolution ITU-R 1.*

Electronic Publication
Geneva, 2014

REPORT ITU-R BT.2296-0

Example of application of Recommendation ITU-R BT.1895 and Report ITU-R BT.2265 to assess interference to the broadcasting service caused by the impact of IMT systems on existing head amplifiers of collective television distribution systems

(2013)

1 The technical trial

The aim of the trial was to verify the quality of the received TV signal in the home following the switching on of the LTE[1] broadband communication systems. An evaluation criterion of the interference based on the feedback of the affected users has, from one side, the advantage to be realistic but, on the other side, it has the drawback not to guarantee an homogeneous and controllable overage of the data set[2]. To this purpose, it has been decided to perform an analysis based on a radio-electric simulation, starting from the measurement data, using a software tool developed in the European Conference of Postal and Telecommunications (CEPT) integrated with a software module which evaluates the non-linear behaviour of the wideband television distribution amplifier at the user's installation. In fact, a huge amount of work has been done outside Italy to evaluate the impact of the LTE interference on TV receivers and a large amount of bibliography exists about it [1], [2], [3]. By contrast, few studies have been performed on the effects of LTE emissions on wideband television distribution amplifiers, a technology that is widely adopted in Italy and in general in Southern Europe.

2 The interference scenario

At present, the city chosen for the evaluation is the ideal scenario for an LTE experiment. All the UHF channels devoted to the LTE service (61-69) have not been assigned following the analogue switch off; for this reason this locality has been adopted for such an experiment.

A total of three hypothetical radio base stations have been identified suitable to host LTE systems. DVB-T services are guaranteed by different transmitting sites, two of which are predominant and received from two different directions. Hence, except in particular cases, it can be assumed that the users' receiving installations are quite homogeneous and made up of two distinct antennas, each one oriented in the appropriate polarization and orientation, a combiner and a wideband amplifier. To mitigate LTE interference, a low-pass filter can be inserted immediately before the amplifier. In Italy the characteristics of the filter have to fit the specification contained in the CEI Guide 100-7 [4].

---

[1] Long Term Evolution (3GPP 4G technology).

[2] The presence of a complaint of malfunctioning does not indicate necessarily a problem referable to the interference of LTE, but on the other hand the absence of complaints of the disturbance does not indicate the absence of the problem (many users could not be aware of the real cause of the disturbance or they might not be watching to programmes conveyed by the channels affected by the problem). The DVB-T system has been designed to have some margins on statistical elements, i.e. propagation and interferences from other services. Hence it is necessary to conduct an evaluation on the eroded margin, as indicated from international institutions (Recommendation ITU-R BT.1895 and relevant guidelines for the assessment) and not just on the presence of disturbance on the video.

3 DVB-T transmitters

The city under evaluation is served by two transmitting sites: the first one is *Punta Bore Tesino*, placed on a North-West hill contiguous to the built-up area. The second one is located in the district of *Maiella*, about 90 km away from the city, in the South-South East direction. The different broadcast operators are distributed among these two sites.

In the preparatory part of the simulations, the data (geographical coordinates, channels, ERP, polarization) related to these transmitters have been collected; however, some data were not available. To compensate for this problem, in order to verify the available data, a preliminary campaign of measures has been carried out by Rai Way: this has allowed to measure the effective values of the received field (and contextually, azimuth, polarization) and typology of user antenna. This analysis has allowed to compute the missing data (ERP of some broadcasters). The signals transmitted from Maiella are in horizontal polarization, those from Punta Bore Tesino are in vertical polarization.

Table 1 shows that the DVB-T broadcasters around the city are thirty in total.

TABLE 1

DVB-T channels broadcast in San Benedetto del Tronto

Channel	Broadcasting station	Site	Pol.		Channel	Broadcasting station	Site	Pol.
21	Tele Mare	Maiella	H		40	MUX-4 RAI	Punta Bore Tesino	V
22	RTM	Punta Bore Tesino	V		41	TELE A	Maiella	H
23	ATV7	Maiella	H		42	Rete A MUX-2	Maiella	H
26	MUX-3 RAI	Punta Bore Tesino	V		43	TVRS	Punta Bore Tesino	V
27	TIVU Italia	Maiella	H		44	Rete A MUX-1	Maiella	H
28	TVQ	Maiella	H		45	RETE 8	Maiella	H
29	TRSP	Maiella	H		46	Antenna 10	Maiella	H
30	MUX-2 RAI	Punta Bore Tesino	V		47	TIMB-1	Punta Bore Tesino	V
31	7-Gold	Punta Bore Tesino	V		48	TIMB-3	Punta Bore Tesino	V
32	MUX-1 RAI	Punta Bore Tesino	V		49	MEDIASET-4	Maiella	H
33	eTV Marche	Punta Bore Tesino	V		50	D-Free	Maiella	H
35	Vera TV	Punta Bore Tesino	V		51	TELEMAX	Maiella	H
36	MEDIASET-2	Maiella	H		52	MEDIASET-1	Maiella	H
38	n.i.	Maiella	H		56	MEDIASET-5	Maiella	H
39	TV Centro Marche	Punta Bore Tesino	V		60	TIMB-2	Punta Bore Tesino	V

4 LTE base stations

The possible transmitting sites identified are called: "BS-LTE North" located in the centre-north of the town; "BS-LTE Centre" located in the central part of the town, while the "BS-LTE South" site is in the south of the town area.

Table 2 reports the main technical parameters chosen for the LTE sites in agreement with ITU Document 6A/166 [5]. The power (ERP) varies from a minimum of 48.5 dBm (71 W) to a maximum of 60 dBm (1 kW). An attenuation of 3 dB between the polarization of the LTE signal and those of the TV signals should be taken into account in the evaluation of the interference.

TABLE 2

LTE sites characteristics

Antenna height (m)	20/30
Power min/max (dBm)	33.5/45
Antenna gain (dB)	15
ERP min/max (dBm)	48.5/60
Signal bandwidth (MHz)	10
LTE blocks	A, B, C
Centre frequency (MHz) for block B	806
Antenna directions	N-S-E

5 The simulation software

The interference analysis was based on simulations; these were performed using a tool set including:

1) a simulation tool for the radio-electric study, SEAMCAT[3] (Spectrum Engineering Advanced Monte Carlo Analysis Tool), a statistical simulation tool developed by the CEPT Working Group Spectrum Engineering which uses the Monte Carlo method to assess the potential interfering effects between the different radio communication terrestrial systems;

2) a software module which evaluates the non-linear behaviour of the wideband distribution amplifier.

The results are represented in graphic form on a map.

5.1 Calibration of the software model

As mentioned above, not all the data of the DVB-T transmitters were known *a priori*. So a preliminary measurement campaign has been carried out by Rai Way, allowing to collect the effective values of received field strength (and contextually, azimuth, polarization) and typology of user antennas.

One of the measurement points, not far from the centre of the town, and at the same time in full visibility from the directions of Punta Bore Tesino and Maiella DVB-T transmitters, has been chosen as a reference.

---

[3] www.SEAMCAT.org.

This has allowed to obtain the missing data (ERP of some broadcasting transmitters), using the SEAMCAT simulation tool itself: to this purpose the victim receiver has been located at the above-mentioned measurement point, and the ERPs of the DVB-T transmitters, placed at their own coordinates and altitude, have been calibrated in order to obtain the measured field strength. Since the measurement point has been chosen in a position in sight of the DVB-T transmitters, as a first step the free space propagation model has been used, with the victim receiver having an isotropic antenna. Comparing the values of ERP with the ones corresponding to the known transmitters, the (small) corrective term with respect to the free space propagation has been determined. From the knowledge of the field strength values (and hence of power[4]) measured in the same point, the values of ERP of the transmitters have been derived for each of the unknown DVB-T channels.

5.2 Simulation of the scenarios

Once defined the parameters of the DVB-T and LTE transmitters, the JTG 5-6 model, [6] has been chosen for the radio wave propagation prediction.

A set of grids of simulation points have been defined and by means of a generation software; the scenarios associated at each single point have been generated, recalculating every pair of receivers coordinates[5]; the antenna diagram of the receiver is reconstructed at each geographic point by combining the two antenna diagrams, according to the two pointing directions.

Hence, each geographic point (scenario) has been simulated with SEAMCAT, extracting the power levels of every (all DVB-T and all LTE) signal at the receiver front end (i.e. the distribution amplifier). These results constitute the data at the input of the inter-modulation simulation module, described in the following section.

5.3 Simulation tool for the intermodulation

This second tool implements the following functionalities:

1) Extraction and interpretation of the results obtained from the first module.

2) Adjustment of the amplifier gain according to the received signal levels from the antenna for each simulated point (it is supposed that the amplifier has been adjusted by the TV antenna installer before the introduction of the LTE signals).

The nominal output level of the amplifier should be properly reduced with respect to the value reported in the data sheet, according to the following formula [4]:

$$\Delta P = 10 \log (n_c - 1)$$

where n_c is the number of distributed channels.

1) Analytical calculations, channel by channel, of the power of the intermodulation products generated by the input signals (only DVB-T, DVB-T + LTE, with or without LTE filters) [7].

---

[4] The formula used to convert the values of the field strength to power level is the following:

$E[\text{dB}\mu\text{V/m}] = V[\text{dB}\mu\text{V}] + K[\text{dBm}^{-1}]$ where: $K = \sqrt{\frac{120 \cdot 4\pi^2}{\lambda^2 R_{rad} G}}[m^{-1}]$ with $R_{rad} = 75\Omega$, $G = 1$ (0 dB for isotropic antenna).

[5] The SEAMCAT simulator uses a multiple reference system in which the position of the Victim Receiver is referred to that of the corresponding transmitter, and the position of each interfering transmitter is referred to that of the Victim Receiver.

Each of the DTT and LTE signals are represented as a number N of equally spaced carriers, distributed within the relevant bandwidth (i.e. 8 MHz for DTT channels, 10 MHz for LTE channels), having a power equal to 1/N of the signal power. The number N has to be chosen high enough to reduce the inaccuracy, but the higher the vale the greater the simulation time. In these simulations, a value of N = 10 has been chosen.

The results are provided as files in textual format, used by the successive functions, and that can be post-processed with other tool (i.e. with Microsoft Excel) for further evaluations.

2) Interpretation of the results according to criteria conveniently chosen (see § 7): each point is associated to a value on a scale of colours.

3) Generation of a file in KML (Keyhole Markup Language) format for the graphical representation of the results using Google Earth.

The required processing time depends on the number of signals, but it can be estimated of the order of 1 minute for simulated point and scenario[6].

6 Modelling of the system

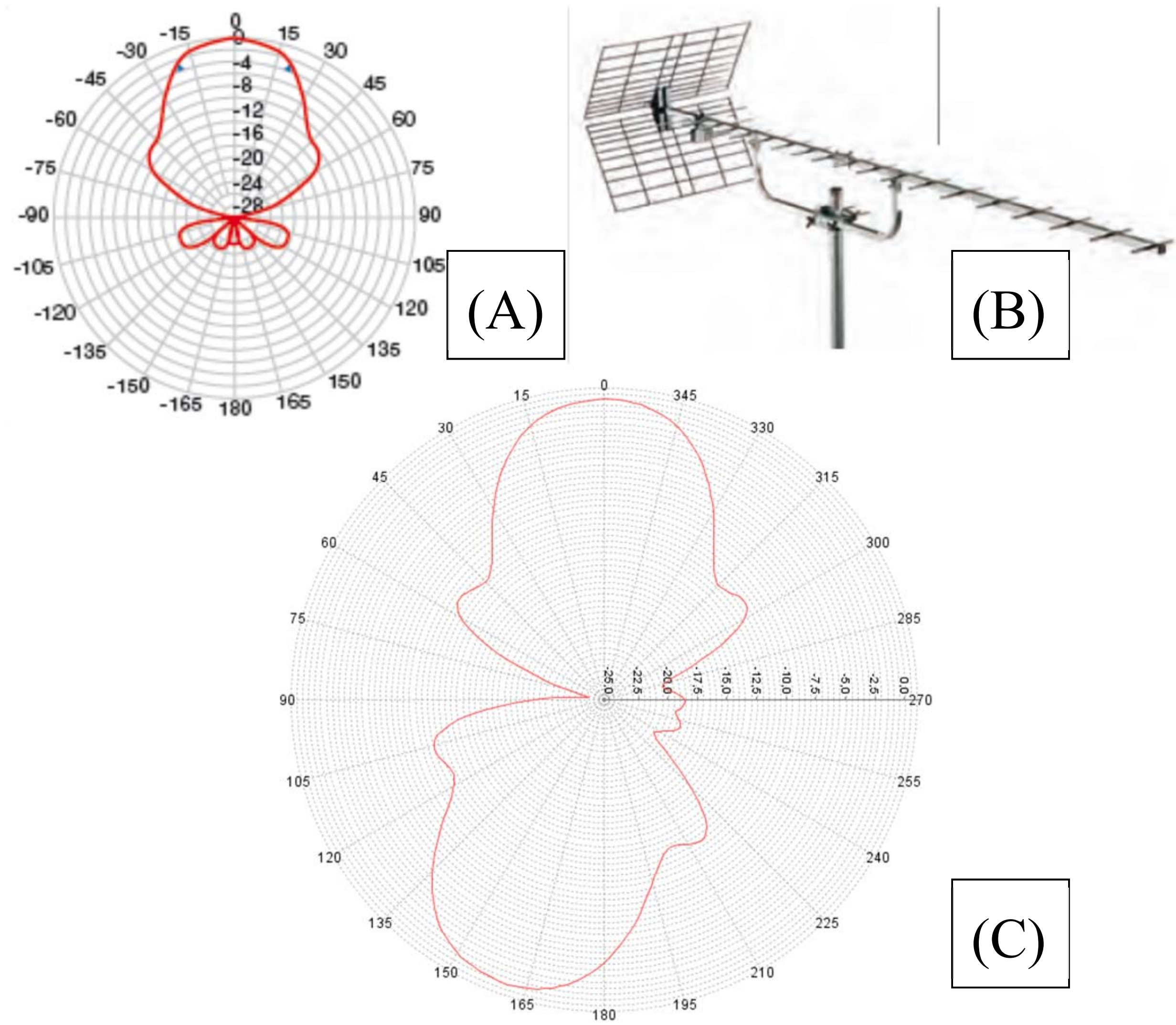
6.1 Antenna

As mentioned in § 3, from a preliminary analysis carried out by Rai Way in the area of interest, the types of antennas on the roof of the buildings have been surveyed. The users' receiving installation are typically made of two identical antennas (or a bit different in terms of effective gain), e.g. a twenty elements Yagi antenna.

[6] On a PC with Intel Core 2 processor @ 2.13 GHz, 2 GByte RAM.

FIGURE 1

A) Diagram of the Yagi antenna; B) A Yagi antenna;
C) Diagram of two combined Yagi antennas (161° case)



Hence a typical commercial model has been considered: in Fig. 1 the antenna (B) is reported, together with the irradiation diagram of the single Yagi (A). The maximum nominal gain of this antenna is 15 dB. In the simulations a system with two combined antennas, of the same type has been adopted, one in vertical polarization, pointed towards Punta Bore Tesino, and the other in horizontal polarization pointed towards Maiella. In Fig. 1C the combined antenna diagram, for the case of 161° mutual orientation, is reported as an example.

6.2 Wideband UHF amplifier

The wideband UHF amplifier has been modelled approximating the input-output behaviour with his power series development truncated at the third order [7]. The technical characteristics, reported in Table 3, are referred to a commercial equipment.

TABLE 3

Technical specifications of the modelled amplifier

Nominal level	112 dB(μV)
2° order IMD	–48 dB
3° order IMD	–54 dB

The noise inside the in-building distribution system has been determined on the basis of the typical noise level of a DVB-T receiver, equal to 7 dB [8], applying a further margin of 4 dB to include the active and passive components of the MATV network [4].

7 Criteria for performance assessment

The protection of the broadcasting service from other services, having allocated spectrum or not, operating in the frequency bands assigned to the broadcasting, has been object of study at international level by the ITU for many years, started after WRC-07. The studies will continue at least up to the next conference scheduled for 2015.

The results already available have produced a new Recommendation ITU-R BT.1895, came into force in May 2011, a new revision of Recommendation ITU-R BT.1368 with the introduction of the concept of overload threshold, besides the classical concept of protection ratio and Report ITU-R BT.2265 on the evaluation of the reception location probability degradation.

The criteria for the protection of the broadcasting services derive from the need to protect a planned service keeping in mind well-defined actors and not others, unknown at the moment of the planning (GE06). Therefore, the criteria contained in Recommendation ITU-R BT.1895 consist of two phases: the first one defines the entity of the interference that can be neglected with respect to the service, the second one aims at quantifying the interference once ensured that it is not negligible.

The basic criterion says that the total interference produced by all the new sources must not exceed a fixed percentage of the overall noise power of the system. Such criterion, named of the *I*/*N*, requires that the interference associated to all the new sources must not exceed the 10% of the total noise power at the receiver. This value, in terms of degradation of the existing *C*/*N* means that the total interference produced by the new sources can be considered negligible if it does not impair such ratio for more than 0.5 dB.

In cases the above ratio is exceeded, additional criteria are considered for the quantification of the impact of the interference. Among the possible methodologies, some of them evaluate the *C*/*N* degradation or the "Reception Location Probability" (RLP) degradation. This evaluation is always done comparing the "after" with the "before". In this case, the above-mentioned N, evaluated in the "before", includes the interference pre-existing at the introduction of the interfering signals object of analysis.

7.1 Trigger threshold evaluation (Recommendation ITU-R BT.1895)

The above-described Trigger Threshold Evaluations must be conducted only in the points inside the DVB-T planned service areas. For the purpose of this study, the degradation is evaluated in dB as:

$$\Delta(C/(N \oplus N_{int})_{deg}) = (N \oplus N_{int})_{after} - (N \oplus N_{int})_{before}$$

The interference N_{int} is caused by the intermodulation contribution which is added to the thermal noise within the received channels in each evaluation point (atmospheric noise and man-made noise are considered negligible at the frequencies of interest). Such contribution is present both "before", because of the intermodulation among the DVB-T channels, and "after", due to the intermodulation among the DVB-T channels and the out-of-band IMT signals falling inside the distribution amplifier bandwidth. Its amount can be considered spread on all the received channels at the reference point[7]. The transfer function between the out-of-band interfering power and in band interfering power is a non-linear type. The value of $C/(N \oplus N_{int})_{ref}$ to be considered as reference in the condition "before" for SFN networks with 64-QAM, CR = 3/4 and RLP = 95% for fixed reception is given by:

$$C/(N \oplus N_{int})_{ref} = EPT + \mu * \delta = 24 + 9 = 33 \text{ dB}$$

where:

EPT: Effective Protection Target

μ: Statistical factor corresponding to a given percentage location probability

δ: Standard deviation of the DVB-T field.

The simulations have been performed in two scenarios:

– One interfering LTE signal (Block B, 10 MHz bandwidth).

– Three interfering LTE signals (Blocks A, B and C).

In both scenarios, the performance of the receiving installations have been evaluated according to the criteria defined in § 7, in 200 geographic points selected over a grid (longitude separation 210 m, latitude separation 250 m). Table 4 reports the statistics on $C/(N \oplus N_{int})_{deg}$ degradation in the two scenarios.

TABLE 4

Statistics on $C/(N \oplus N_{int})_{deg}$ degradation

$C/(N \oplus N_{int})_{deg}$ degradation	LTE Block B	LTE Blocks A, B and C
≤ 0.5 dB	51.5%	27.5%
> 0.5 dB	48.5%	72.5%

Table 5 reports the statistics on RLP degradation in the two scenarios.

TABLE 5

Statistics RLP degradations

	LTE Block B	LTE Blocks A, B and C
$C/(N \oplus N_{int})_{after} \geq 33$ dB on all channels	66.5%	38.5%
$C/(N \oplus N_{int})_{after} < 33$ dB on at least one channel	33.5%	61.5%

In each simulation point, only the DVB-T channels having a RLP "before" > 95% (i.e. $C/(N \oplus N_{int})_{before} > 33$ dB) have been considered for the interference evaluation. Therefore, the percentages relevant to "$C/(N \oplus N_{int})_{after} < 33$ dB" reported in Table 5 are relevant to the points where at least one of the DVB-T channels passes from above to below the 33 dB threshold.

[7] In case LTE Block A is also present, a higher inter-modulation contribution is expected at the highest DVB-T frequencies because of the shoulders effect.

Figure 2 shows the RLP degradation in the area (red dots: $C/(N \oplus N_{int})_{after} < 33$ dB) and the position of the set of points where in deep RLP degradation evaluation has to be performed.

7.2 Reception location probability degradation (Report ITU-R BT.2265)

The RLP degradation analysis has been performed in the points numbers 1, 2 and 3 that are indicated in the Figure.

In particular, point 1 has been chosen to be in the main lobe of the receiving antenna; point 2 on the back of the LTE BS transmitting antenna while point 3 is located at about 250 m from LTE BS without attenuation of the receiving antenna.

Due to the specific locations of the transmitting sites as described in § 3, the DVB-T channels are received in antenna with different signal levels: in the northern part of the area, close to the Punta Bore Tesino transmitter, some of them are significantly higher than the others, while in the southern part the signal levels are more homogeneous. As a consequence, the number of channels considered as receivable changes along the simulation area, i.e. from 15 channels in the northern points and 28 channels in the southern points over the 30 channels available off the air.

Importantly, this analysis specifically takes into account the cases which are not immediately detected at the switch-on of an LTE Base Station, but which lose their protection margin in presence of time-varying phenomena (e.g. propagation).

FIGURE 2

RLP degradation, three LTE interfering signals (Blocks A, B and C)

For each DVB-T channel, the calculation of the reception location probability and the degradation to the reception location probability is carried out using a Monte Carlo methodology which takes into account the statistical variations (temporal and spatial) of all the parameters.

In particular, the wanted DVB-T field strength has been considered at 50% of the time, while the interfering LTE field strength at 1% of the time (will have negligible differences if 50% of the time is considered). In addition, a large number of statistical samples have been used to give statistical significance to the results.

Considering that national and regional wide SFNs have been planned and deployed in Italy, each sample C_w has been compared with the nuisance field N_{nuis} given by:

$$N_{nuis} = (\mathrm{N} \oplus \mathrm{N}_{\mathrm{int}})_{\mathrm{before\ /\ after,}} + \mathrm{EPT}$$

where EPT is given by (see Table 6):

$$\mathrm{EPT} = (C/N)_{ref} + SFN_{margin}$$

$$(C/N)_{ref} = \textit{for Ricean channel}$$

From thousands of measurements made in Italy on SFNs is resulted that the power sum of the artificial echoes is less than 2 dB with respect to the main echo in the 1.5% of the cases. Therefore, an SFN_{margin} of 5 dB has been chosen.

Table 6
EPT

CHANNELS	MOD	CR	EPT
21	64 QAM	3/4	23.9
22	64 QAM	3/4	23.9
23	64 QAM	5/6	25.4
26	64 QAM	2/3	22.3
27	64 QAM	1/2	19.3
28	64 QAM	2/3	22.3
29	64 QAM	3/4	23.9
30	64 QAM	2/3	22.3
31	64 QAM	3/4	23.9
32	64 QAM	3/4	23.9
33	64 QAM	5/6	25.4
35	64 QAM	2/3	22.3
36	64 QAM	5/6	25.4
38	16 QAM	1/2	14.8
39	64 QAM	2/3	22.3
40	64 QAM	2/3	22.3
41	64 QAM	3/4	23.9
42	64 QAM	5/6	25.4
43	64 QAM	2/3	22.3
44	64 QAM	3/4	23.9
45	64 QAM	3/4	23.9
46	64 QAM	3/4	23.9
47	64 QAM	3/4	23.9
48	64 QAM	3/4	23.9
49	64 QAM	3/4	23.9
50	64 QAM	5/6	25.4
51	64 QAM	1/2	19.3
52	64 QAM	5/6	25.4
56	64 QAM	5/6	25.4
60	64 QAM	3/4	23.9

Finally, the comparison is made:

– if $C_w \geq N_{nuis}$, then the "trial" is noted as being "acceptable reception";

– if $C_w < N_{nuis}$ then the "trial" is noted as being "unacceptable reception".

The simulations have been performed in two scenarios:

– One interfering LTE signal (Block B, 10 MHz bandwidth), see Figs 3 to 5;

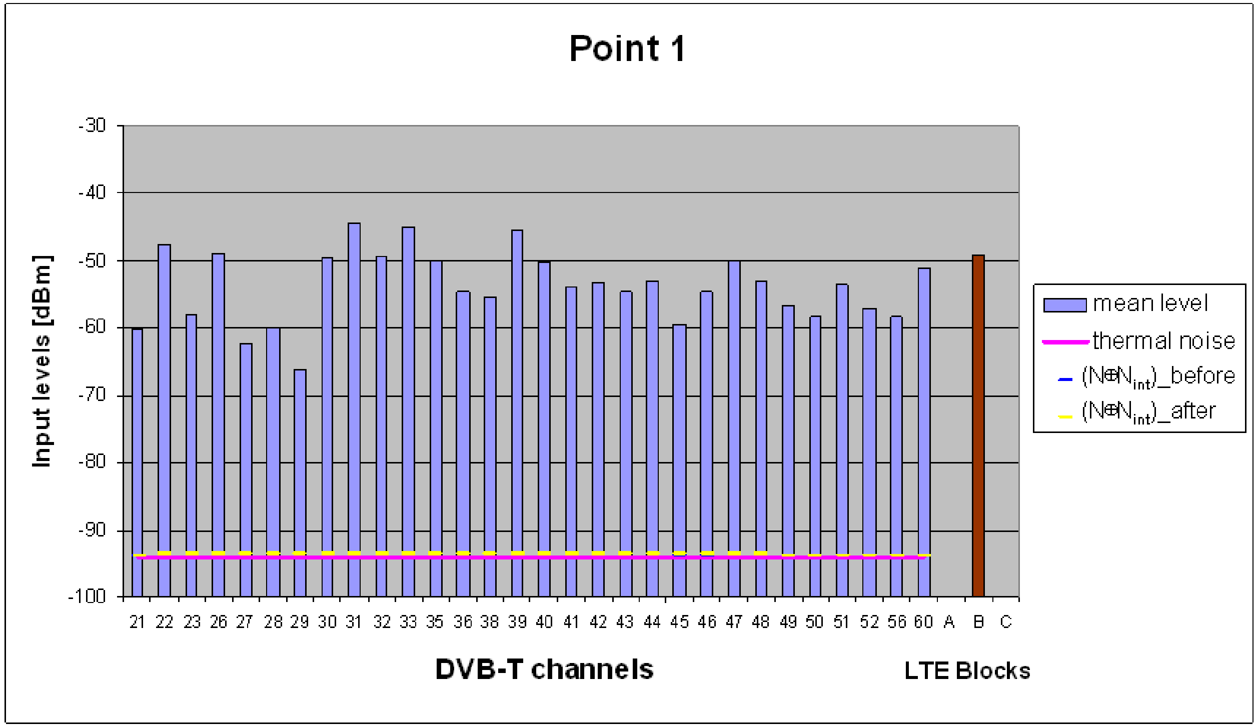
– Three interfering LTE signals (Blocks A, B and C), see Figs 6 to 8.

In each Figure, the following results are reported:

– the power of each DVB-T channel before the head amplifier (mean level);
– the power of LTE signals, taking into account the reception antenna irradiation diagram;
– the thermal Noise;
– the $(N \oplus N_{int})_{before}$;
– the $(N \oplus N_{int})_{after}$;
– the RLP_{before};
– the RLP_{after};
– the RLP_{loss}.

FIGURE 3

Results in Point 1, LTE Block B

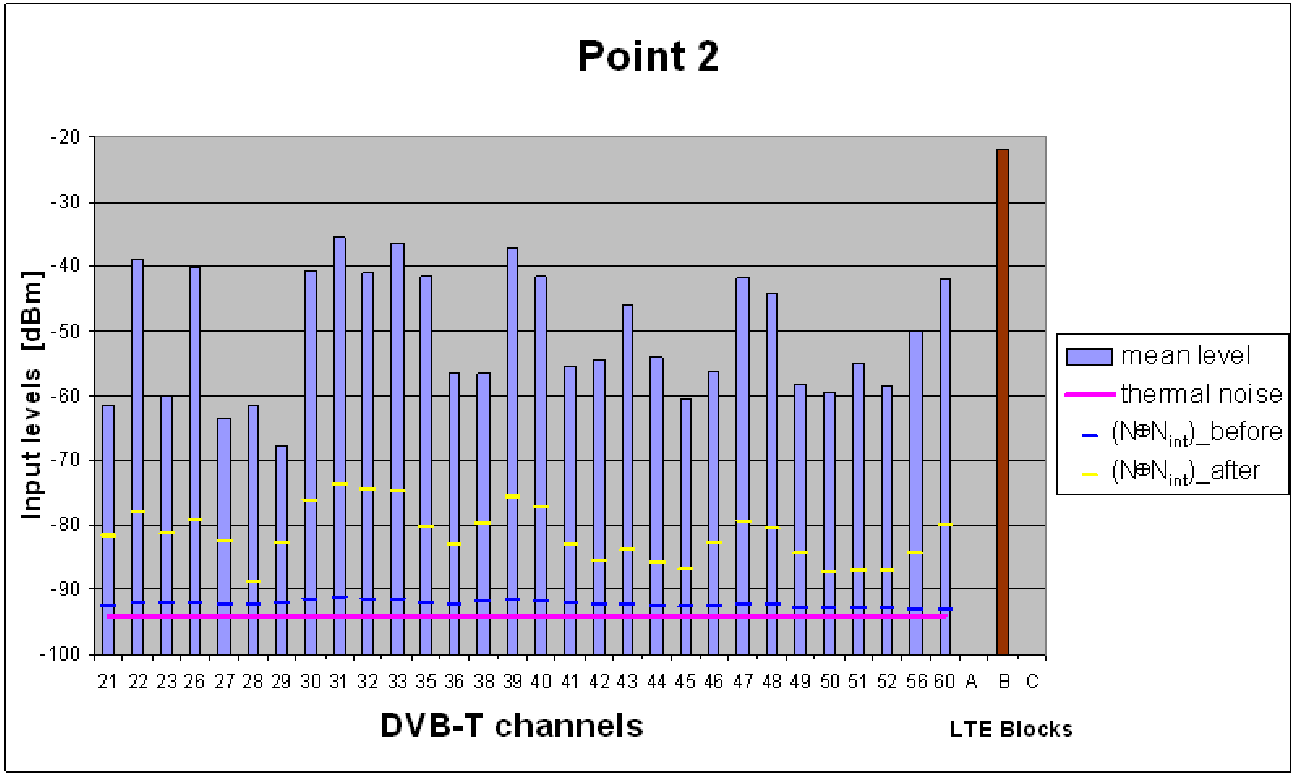


Statistics on RLP degradation of Point 1

CHANNELS	RLP_{before}	RLP_{after}	RLP_{loss}
21	95%	95%	0%
22	100%	100%	0%
23	96%	96%	0%
26	100%	100%	0%
27	99%	99%	0%
28	98%	98%	0%
29	72%	72%	0%
30	100%	100%	0%
31	100%	100%	0%
32	100%	100%	0%
33	100%	100%	0%
35	100%	100%	0%
36	99%	99%	0%
38	100%	100%	0%
39	100%	100%	0%
40	100%	100%	0%
41	100%	100%	0%
42	100%	100%	0%
43	100%	100%	0%
44	100%	100%	0%
45	96%	96%	0%
46	100%	100%	0%
47	100%	100%	0%
48	100%	100%	0%
49	99%	99%	0%
50	97%	97%	0%
51	100%	100%	0%
52	97%	97%	0%
56	97%	97%	0%
60	100%	100%	0%

FIGURE 4

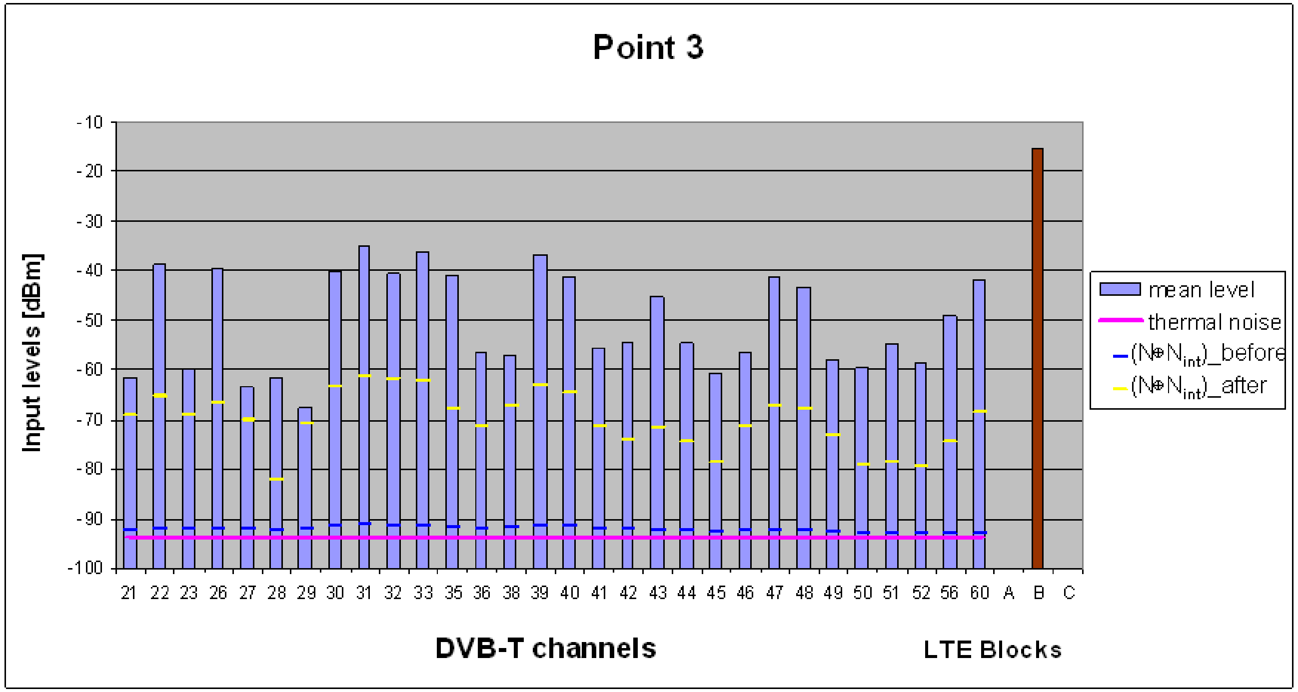
Results in Point 2, LTE Block B



Statistics on RLP degradation of Point 2			
CHANNELS	RLP_{before}	RLP_{after}	RLP_{loss}
21	90%	43%	47%
22	100%	100%	0%
23	85%	40%	45%
26	100%	100%	0%
27	94%	58%	36%
28	92%	78%	14%
29	47%	14%	33%
30	100%	99%	1%
31	100%	100%	0%
32	100%	96%	4%
33	100%	100%	0%
35	100%	100%	0%
36	96%	64%	32%
38	100%	79%	21%
39	100%	100%	0%
40	100%	99%	1%
41	98%	77%	21%
42	99%	82%	17%
43	100%	100%	0%
44	100%	91%	9%
45	93%	65%	28%
46	98%	69%	29%
47	100%	100%	0%
48	100%	98%	2%
49	97%	68%	29%
50	93%	63%	30%
51	100%	99%	1%
52	94%	70%	24%
56	100%	96%	4%
60	100%	100%	0%

FIGURE 5

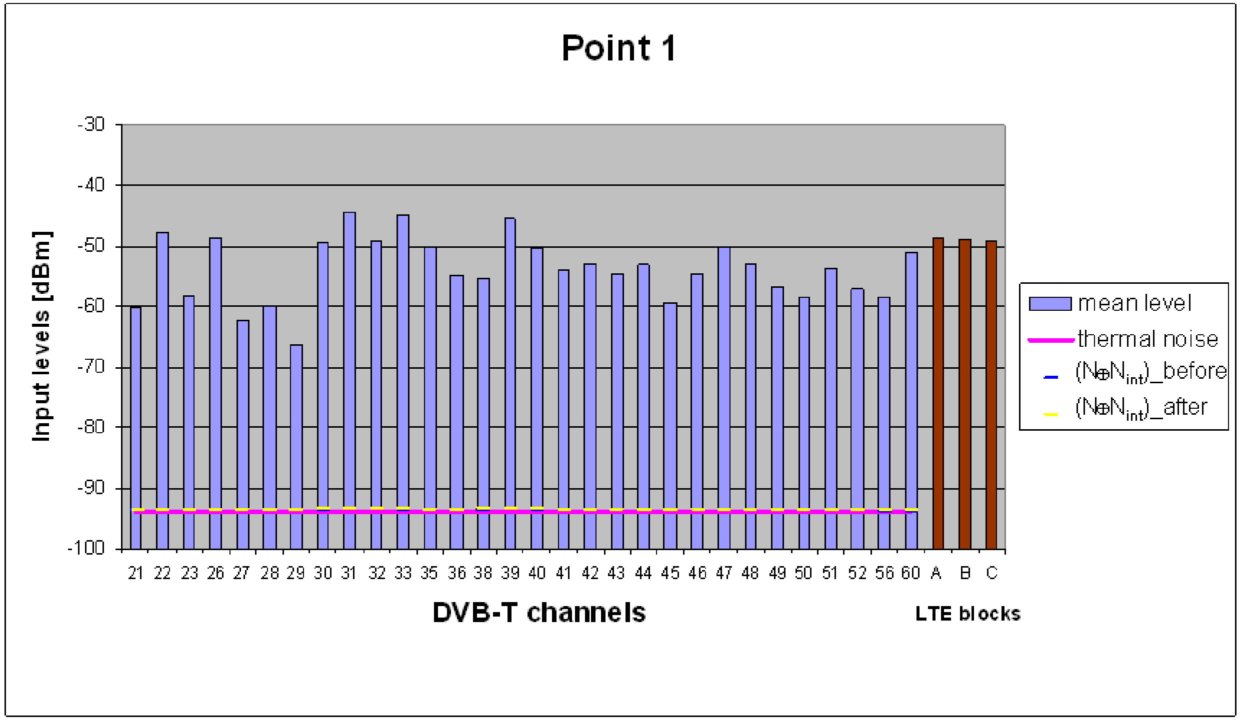
Results in Point 3, LTE Block B



Statistics on RLP degradation of Point 3			
CHANNELS	RLP_{before}	RLP_{after}	RLP_{loss}
21	89%	14%	75%
22	100%	73%	27%
23	86%	13%	73%
26	100%	79%	21%
27	94%	22%	72%
28	93%	40%	53%
29	47%	5%	42%
30	100%	63%	37%
31	100%	67%	33%
32	100%	49%	51%
33	100%	63%	37%
35	100%	77%	23%
36	96%	25%	71%
38	100%	31%	69%
39	100%	74%	26%
40	100%	63%	37%
41	98%	31%	67%
42	99%	35%	64%
43	100%	75%	25%
44	100%	43%	57%
45	91%	26%	65%
46	98%	26%	72%
47	100%	66%	34%
48	100%	62%	38%
49	97%	26%	71%
50	91%	25%	66%
51	100%	73%	27%
52	94%	30%	64%
56	100%	58%	42%
60	100%	71%	29%

FIGURE 6

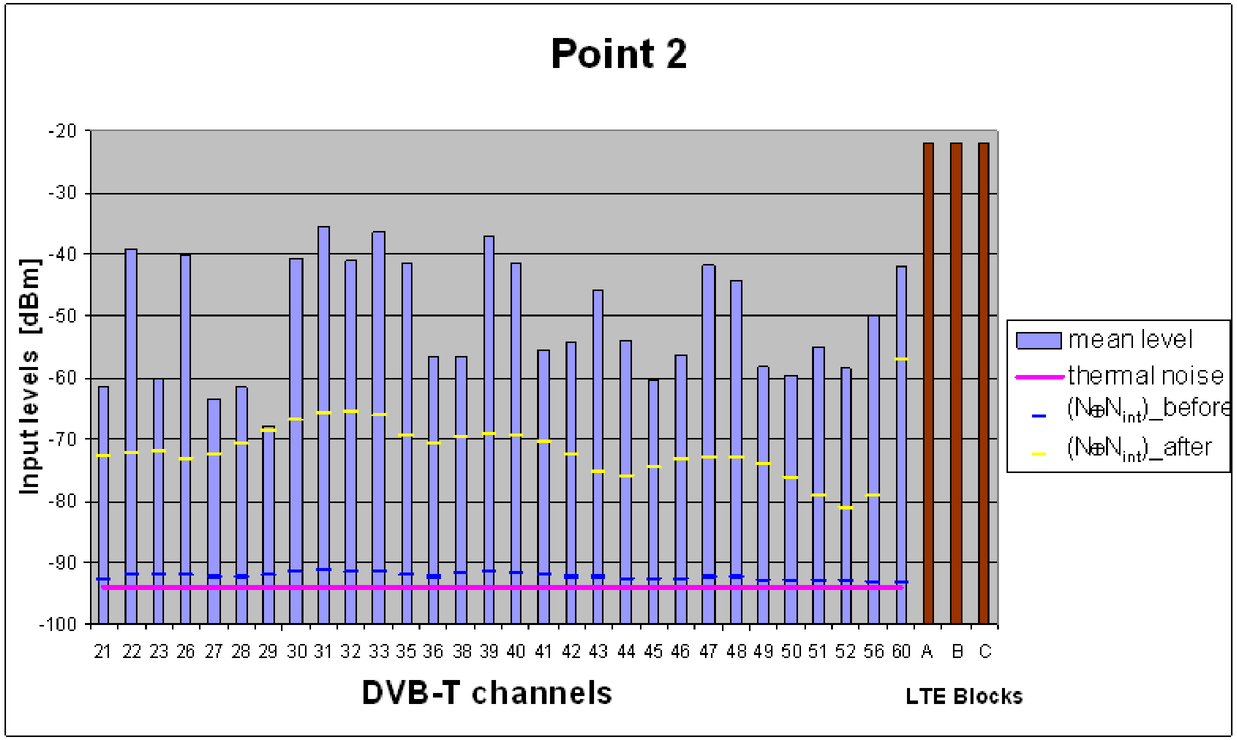
Results in Point 1, 3 LTE Blocks (A, B, C)



Statistics on RLP degradation of Point 1			
CHANNELS	RLP_{before}	RLP_{after}	RLP_{loss}
21	95%	95%	0%
22	100%	100%	0%
23	96%	95%	1%
26	100%	100%	0%
27	99%	99%	0%
28	98%	98%	0%
29	72%	71%	1%
30	100%	100%	0%
31	100%	100%	0%
32	100%	100%	0%
33	100%	100%	0%
35	100%	100%	0%
36	99%	99%	0%
38	100%	100%	0%
39	100%	100%	0%
40	100%	100%	0%
41	100%	100%	0%
42	100%	100%	0%
43	100%	100%	0%
44	100%	100%	0%
45	96%	96%	0%
46	100%	100%	0%
47	100%	100%	0%
48	100%	100%	0%
49	99%	99%	0%
50	97%	97%	0%
51	100%	100%	0%
52	97%	97%	0%
56	97%	97%	0%
60	100%	100%	0%

FIGURE 7

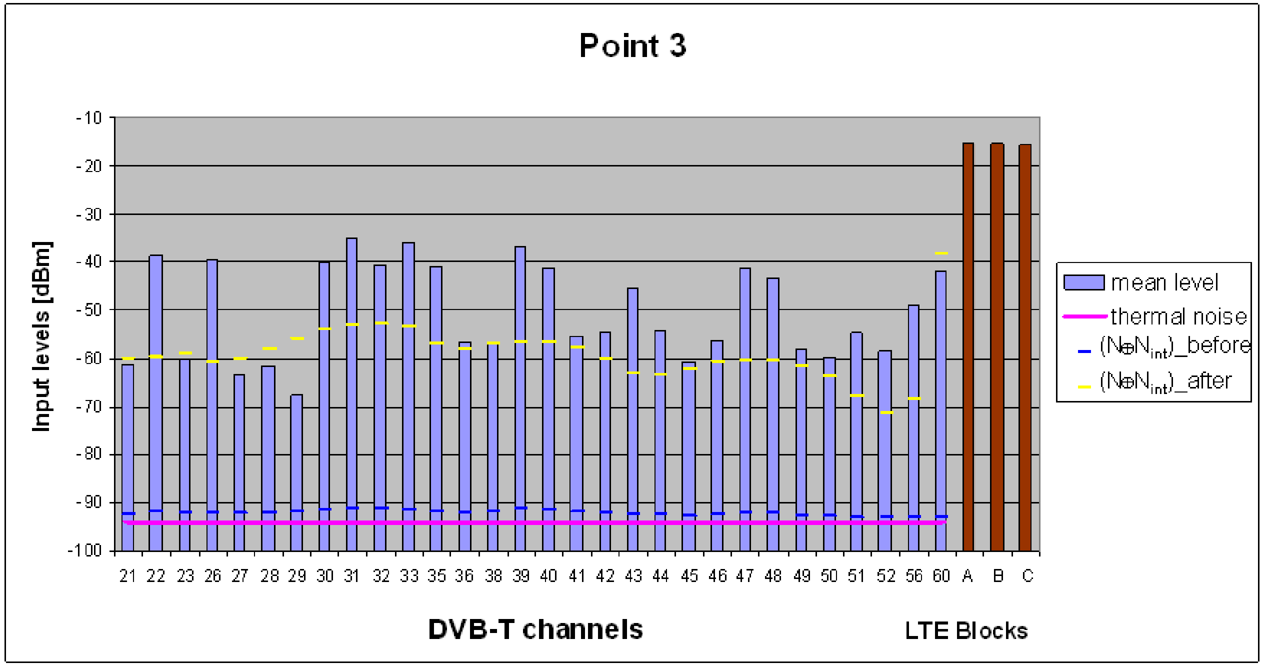
Results in Point 2, 3 LTE Blocks (A, B, C)



Statistics on RLP degradation of Point 2			
CHANNELS	RLP_{before}	RLP_{after}	RLP_{loss}
21	90%	10%	80%
22	100%	100%	0%
23	85%	5%	80%
26	100%	100%	0%
27	94%	12%	82%
28	92%	7%	85%
29	47%	0%	47%
30	100%	82%	18%
31	100%	90%	10%
32	100%	60%	40%
33	100%	83%	17%
35	100%	90%	10%
36	96%	8%	88%
38	100%	23%	77%
39	100%	98%	2%
40	100%	86%	14%
41	98%	14%	84%
42	99%	19%	80%
43	100%	93%	7%
44	100%	43%	57%
45	93%	9%	84%
46	98%	22%	76%
47	100%	95%	5%
48	100%	86%	14%
49	97%	17%	80%
50	93%	11%	82%
51	100%	81%	19%
52	94%	28%	66%
56	100%	79%	21%
60	100%	21%	79%

FIGURE 8

Results in Point 3, 3 LTE Blocks (A, B, C)



Statistics on RLP degradation of Point 3			
CHANNELS	RLP_{before}	RLP_{after}	RLP_{loss}
21	89%	0%	89%
22	100%	29%	71%
23	86%	0%	86%
26	100%	36%	64%
27	94%	0%	94%
28	93%	0%	93%
29	47%	0%	47%
30	100%	12%	88%
31	100%	16%	84%
32	100%	7%	93%
33	100%	11%	89%
35	100%	17%	83%
36	96%	0%	96%
38	100%	2%	98%
39	100%	30%	70%
40	100%	16%	84%
41	98%	1%	97%
42	99%	1%	98%
43	100%	21%	79%
44	100%	2%	98%
45	91%	1%	90%
46	98%	1%	97%
47	100%	19%	81%
48	100%	14%	86%
49	97%	1%	96%
50	91%	0%	91%
51	100%	19%	81%
52	94%	2%	92%
56	100%	10%	90%
60	100%	1%	99%

8 Conclusions

The analysis made by Rai and Rai Way on the results of the experiment described above, which was conducted to study the impact of emissions of LTE systems on digital terrestrial television broadcasting services when such services are distributed through collective antenna systems, has highlighted that such impact is much greater than the one normally expected when television signals are received through the use of individual antennas, due mainly to the non-linearity found in distribution amplifiers of centralized antenna systems when the input signal levels are higher than the nominal value. Such impact is worse when the interference comes from more than one interfering emission and when they are originated by the same BS site (co-siting), to the point that putting appropriate filters placed upstream from the collective antenna amplifier could become less and less effective. Co-siting is one of the most effective actions undertaken by operators to reduce the capex and the opex and is considered into actions from the Radio Spectrum Policy Group (RSPG).

Therefore the following items should be considered in the interference assessment procedure when DVB-T services are distributed through collective antenna systems:

– use of Recommendation ITU-R BT.1895 to determine the trigger threshold;
– use of Report ITU-R BT.2265 to determine the protection margin loss above which coordination or mitigation actions have to be performed;
– use of Report ITU-R BT.2265 to determine the residual protection margin loss after coordination or mitigation actions implementations;
– consider, in the determination of the residual protection margin loss after mitigation actions implementations, the increase of the noise figure of the receiving system due to the adoption of the mitigation actions.

References

[1] CEPT Report 30: Report from CEPT to the European Commission in response to the Mandate on "The identification of common and minimal (least restrictive) technical conditions for 790-862 MHz for the digital dividend in the European Union", October 2009.
http://www.erodocdb.dk/Docs/doc98/official/pdf/CEPTREP030.pdf

[2] B. Randhawa, I. Parker, S. Antwi: LTE Interference into Domestic Digital Television Systems, Cobham Report 2010-0026, January 2010.
http://stakeholders.ofcom.org.uk/binaries/consultations/800mhz/statement/2010-0026.pdf

[3] Ofcom: Technical analysis of interference from mobile network base stations in the 800 MHz band to digital terrestrial television, Technical Report, June 2011.
http://stakeholders.ofcom.org.uk/binaries/consultations/dtt/annexes/Technical-Report.pdf

[4] CEI 100-7, *Guida per l'applicazione delle Norme sugli impianti di ricezione televisiva*, December 2012.

[5] ITU-R Doc. 6A/166, WP 5D: Liaison statement to Joint Task Group 4-5-6-7. Sharing parameters for WRC-15 agenda item 1.2.

[6] JTG 5-6(09)053, JTG 5-6 propagation model.

[7] D. Milanesio, B. Sacco, V. Sardella: *LTE e DTT: Effetti dei segnali per la telefonia mobile di 4a generazione sugli attuali impianti d'antenna televisivi*, Elettronica e Telecomunicazioni, n° 3, December 2011,
http://www.crit.rai.it/eletel/2011-3/113-6.pdf

[8] ETSI TR 101 190 – Digital Video Broadcasting (DVB); Implementation guidelines for DVB terrestrial services; Transmission aspects.